

Atty. Dkt. No.: 60,680-754  
Dana Ref. No.: 6616 SIAE  
Express Mail No.: ET931279085US

## PUMP

This application claims priority to United Kingdom Patent Application No. 0226529.6 filed November 14, 2002, the entire disclosure of which is incorporated herein by reference.

### Background to the Invention

The present invention relates to a pump particularly to a pump including a power screw and at least one idler screw mounted in a housing, the idler screw which meshes with the power screw such that rotation of the power screw causes rotation of the idler screw.

Such a pump is commonly known as a screw pump, and pumping of fluid within the housing is effected by fluid becoming trapped and pressurised between the meshing screws.

### Description of the Prior Art

Typically, such pumps include one or two cylindrical idler screws. Where two idler screws are provided they are typically mounted on diametrically opposite sides of the power screw. The idler screws need not be attached to the housing but may simply be retained within the housing. Alternatively, the idler screws may be mounted at an end in a bearing provided in the housing. In both cases, the pressure from the pumped fluid exerts a force on the idler screws which tends to push the idler screws away from the power screw into the housing. As a result, frictional forces between the idler screws and the housing can cause significant energy losses. This is a particular problem when the idler screws are not mounted in a bearing.

### Summary of the Invention

According to the invention a pump including a power screw and at least one idler screw which meshes with the power screw, the power screw and idler screw being rotatable in a housing, the idler screw having at least one screw form including a

Atty. Dkt. No.: 60,680-754  
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generally helical groove and a generally helical land surface, the land surface having a first and a second edge portion, each of which is adjacent to the or a groove, the distance between the land surface and a longitudinal axis of the idler screw varying between the first edge portion and the second edge portion, the distance between the first edge portion and the longitudinal axis of the idler screw being substantially constant over the length of the screw form and the distance between the second edge portion and the longitudinal axis of the idler screw being substantially constant over the length of the screw form.

By virtue of the shape of the idler screw, the pumped fluid acts as a hydrodynamic bearing, supporting the idler screw and reducing the frictional forces between the idler screw and the housing.

In one embodiment, the distance between the or the at least one land surface and the longitudinal axis increases continuously from the first edge portion to the second edge portion. In a preferred embodiment, the distance between the or the at least one land surface and the longitudinal axis, initially increases from the first edge portion to a position intermediate the first and second edge portions, and then remains generally constant from the intermediate position to the second edge portion. The intermediate position may be approximately half way between the first and second portions. Such an arrangement may be easier to manufacture and gauge than where the distance increases continuously. Also in use, the hydrodynamic pressure drop between where the second edge portion separates from the adjacent housing wall as the idler screw rotates, and where the next first edge portion engages the housing wall is reduced compared within a continuously ramped arrangement.

In each case, preferably the idler screw is arranged so that the first edge portion leads the second edge portion as the idler screw rotates in use.

The first and/or second edge portion may be slightly radiussed if desired so as to provide a lead-in to the or an adjacent groove.

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Preferably the power screw includes at least one generally helical ridge which engages with the generally helical groove of the or each idler screw.

Preferably, each idler screw includes two generally helical grooves of substantially the same pitch and two generally helical land surfaces, each land surface having a first and a second edge portion, each of which is adjacent to a groove, the distance between each land surface and a longitudinal axis of the idler screw varying between the first edge portion and the second edge portion over at least part of the length of the idler screw. In this case, the power screw includes two generally helical ridges of substantially the same pitch.

Preferably the pump includes two idler screws located at diametrically opposite sides of the power screw.

The difference in the distance between the longitudinal axis of the idler screw and the land surface at the first edge portion and the second edge portion may be up to 4% of the largest distance between the longitudinal axis of the idler screw and the land surface.

An end of the or each idler screw may be mounted in a bearing provided in the housing.

#### Brief Description of the Drawings

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, of which,

FIGURE 1 is an illustration of a power screw and idler screws and a housing of a pump according to the invention,

FIGURE 2 is an illustration of a transverse cross-section through the power screw and idler screws of Figure 1.

FIGURE 2a is a view similar to Figure 2 but showing a preferred idler screw form;

Atty. Dkt. No.: 60,680-754  
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FIGURE 3 is an illustration of a longitudinal section through a pump according to the invention, in the direction shown by arrow X in Figure 2.

FIGURE 4 is an illustration of a longitudinal section through a pump according to the invention in the direction shown by arrow Y in Figure 2.

#### Description of the Proposed Embodiments

Referring now to the figures, there is shown a power screw 10 and idler screws 12 of a screw pump, the two idler screws 12 located at diametrically opposite sides of the power screw 10. Longitudinal axes A of the idler screws 12 are generally parallel to the longitudinal axis B of the power screw 10. Each idler screw 12 has two screw forms which include first and second generally helical grooves 14, 14' which each extend along substantially the entire length of the screw 12. The two grooves 14, 14' are both of substantially the same pitch and sense, and the turns of the grooves 14, 14' are interposed such that when the screw 12 is viewed in transverse cross-section one groove 14 is diametrically opposite the other 14'.

The grooves 14, 14' are separated by first and second generally helical land surfaces 16, 16', each land surface having a first edge portion 16a, 16a' and second edge portion 16b, 16b' adjacent to one of the grooves 14, 14'. The first edge portion 16a of the first land surface 16 is adjacent to the second groove 14' and the second edge portion 16b of the first land surface 16 is adjacent to the first groove 14. The first edge portion 16a' of the second land surface 16' is adjacent to the first groove 14, and the second edge portion 16b' of the second land surface 16' is adjacent to the second groove 14'.

In the Figure 2 embodiment, the distance between each land surface 16, 16' and the longitudinal axis A of the idler screw 12 increases continuously from the first edge portion 16a, 16a' to the second edge portion 16b, 16b'.

In the embodiment of Figure 2a, on which all like parts to those on Figure 2 are labelled with the same references, the distance between each land surface 16, 16' and

Atty. Dkt. No.: 60,680-754  
Dana Ref. No.: 6616 SIAE  
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the longitudinal axis A of the idler screw 12 increases from the first edge portion 16, 16a' continuously to an intermediate position I, I', which intermediate position I, I' is in this example, approximately half way between the respective first and second edge portions 16a, 16a'; 16b, 16b'. From the intermediate positions I, I' to the second edge portions 16b, 16b', the distance between the land surface 16, 16' and the longitudinal axis A of the idler screw 12 is generally constant.

In each example, if desired, the first and/or second edge portions 16a, 16a'; 16b, 16b' may be slightly radiussed so as to provide a lead-in to the adjacent respective groove 14, 14'.

Typically, the difference in the distance between the first edge portion 16a, 16a' of each land surface 16, 16' and the longitudinal axis A and the distance between the second edge portion 16b, 16b' of each land surface 16, 16' and the longitudinal axis A is up to 4% of the largest outside diameter of the idler screw 12, i.e. the distance between the second edge portion 16b, 16b' of each land surface 16, 16' and the longitudinal axis A. Thus it is apparent that this difference has been exaggerated in Figures 2 and 2a for clarity.

The power screw 10 and idler screw 12 are both generally cylindrical, however, and thus it will be appreciated that the distance between each first edge portion 16a, 16a' and the longitudinal axis A of the idler screw 12 is substantially constant over the length of the idler screw 12, as is the distance between each second edge portion 16b, 16b' and the longitudinal axis A.

The power screw 10 is provided with first 18 and second 18' generally helical ridges which each extend along substantially the entire length of the screw 10. The two ridges 18, 18' are both of substantially the same pitch & sense, and the turns of the ridges 18, 18' are interposed such that when the screw 10 is viewed in transverse cross-section, one ridge 18 is diametrically opposite the other 18'.

Atty. Dkt. No.: 60,680-754  
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The first ridge 18 meshes with the first groove 14 of each idler screw 12, and the second ridge 18' meshes with the second groove 14' of each idler screw 12, and thus rotation of the power screw 10 about its longitudinal axis B in the direction indicated by the respective arrow, causes rotation of the idler screws 12 about their longitudinal axes A in the opposite rotational direction as indicated by the respective arrows.

The power screw 10 and idler screws 12 are mounted in a housing 20, part of which is illustrated in Figures 2 and 2a, 3 & 4, which is shaped to provide minimum clearance between the screws 10, 12 and the housing 20, whilst permitting rotation of the screws 10, 12 within the housing 20. The housing 20 thus includes an elongate cavity in which the screws 10, 12 are housed. In cross-section, the cavity includes a central part circular portion 20a of a larger diameter adapted to house the power screw 10, and two part circular lobe portions 20b located on diametrically opposite sides of the central portion of 20a, which each have a smaller diameter and are adapted to house the idler screws 12.

As illustrated in Figures 3 & 4, the housing 20 also includes an outlet port 22 and an inlet port 24, the inlet port 24 being arranged such that fluid enters the cavity adjacent to first ends of the driven and idler screws 10, 12 and the outlet port 22 being arranged such that fluid leaves the cavity adjacent to second ends of the driven and idler screws 10, 12. The inlet port 24 is connected to a supply of fluid to be pumped.

The power screw 10 is connected to a motor (not shown) by means of a drive shaft 26, the drive shaft 26 being mounted in bearings 28 provided in the housing 20. Operation of the motor causes the power screw 10 to rotate about its longitudinal axis B in a first sense, and which thus causes the idler screws 12 each to rotate about their longitudinal axes A in an opposite sense to the power screw 10. The screws 10, 12 are oriented such their rotation causes fluid to be drawn from the inlet port and moved along the length of the screws 10, 12 to the outlet port. Fluid trapped between the

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ridges 18, 18' and the grooves 14, 14' as the screws 10,12 mesh becomes pressurised and exerts an outward force on both the idler screws 12, which tends to push the idler screws 12 towards the housing 20.

The idler screws 12 are configured such that the first edge portions 16a, 16a' of each land surface 16, 16' lead the second edge portions 16b, 16b' as the idler screws 12 rotate. The resulting change in separation between the land surfaces 16, 16' and the housing 20 compresses the fluid between the housing 20 and the land surfaces 16, 16', the resultant local fluid pressures enable the fluid to act as a hydrodynamic bearing, supporting the idler screws 12, and reducing frictional forces between the housing and the land surfaces 16, 16' of the idler screws 12. Thus, the efficiency of the pump is improved.

Such a pump advantageously is used to pump fluid for hydraulic systems which may include actuators.

In the examples described, the idler screws 12 are not connected to the housing 20, but it is possible to mount the idler screws 12 on bearings connected to the housing 20.

It is not necessary to provide each idler screw 12 with two grooves 14, 14' and the power screw 10 with two ridges 18, 18'. Each idler screw 12 may be provided with one or more than two grooves 14, 14', and the power screw 10 provided with a corresponding number of ridges 18, 18'.